Factors associated with early postoperative feeding: an observational study in a colorectal surgery population

Charlotte Atkinson[a,b], Vaneesha C Monk[c], Andy R Ness[a,b], Stephen J Lewis[d], Robert J Longman[e], Steve J Thomas[b], Sam D Leary[a,b], Will Hollingworth[f], Chris M Penfold[a,f]

[a]National Institute for Health Research Bristol Biomedical Research Centre, University Hospitals Bristol NHS Foundation Trust and University of Bristol, Bristol, UK

[b]Bristol Dental School, University of Bristol, Bristol, UK

[c]Department of Paediatrics, University of Oxford, John Radcliffe Hospital, Oxford, UK

[d]Derriford Hospital, Plymouth Hospitals NHS Trust, Plymouth, UK

[e]University Hospitals Bristol NHS Foundation Trust, Bristol, UK

[f]Bristol Medical School, University of Bristol, Bristol, UK

Corresponding author:

Charlotte Atkinson, PhD

Senior Research Fellow in Nutrition

NIHR Bristol Biomedical Research Centre (Nutrition Theme)

Level 3, University Hospitals Bristol Education Centre

Upper Maudlin Street

Bristol BS2 8AE

Ph: (0117) 342-1766

e-mail: charlotte.atkinson@bristol.ac.uk

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Abstract

Background and aims: Early post-operative feeding is recommended within enhanced recovery after surgery programmes. This study aimed to describe post-operative feeding patterns and associated factors among patients following colorectal surgery, using a post-hoc analysis of observational data from a previous RCT on chewing gum after surgery.

Methods: Data from 301 participants (59% male, median age 67y) were included. Amounts of meals consumed on post-operative days (POD) 1-5 were recorded as: none, a quarter, half, three-quarters, all. 'Early' consumers were those who ate ≥ a quarter of a meal on POD1. 'Early' tolerance was the consumption of at least half of three meals on POD1 or 2 without vomiting. Exploration of selected peri-operative factors with early feeding and tolerance were assessed using logistic regression.

Results: 222 people (73.8%) consumed solid food early, and 109 people (36.2%) tolerated solid food early. Several factors were associated with postoperative feeding: provision of pre-operative bowel preparation was associated with delayed consumption [odds ratio (OR) 0.34, 95% confidence interval (CI) 0.14-0.83] and tolerance (OR 0.35, 95% CI 0.16-0.81) of food; and laparoscopic/laparoscopic assisted (vs. open/converted to open surgery) was associated with early tolerance of food (OR 1.99, 95% CI 1.17-3.39).

Conclusions: While three-quarters of the study population ate solid food early, only one-third tolerated solid food early. Findings suggest that bowel preparation and surgery type are factors warranting further investigation in future studies to improve uptake of early post-operative feeding.

Introduction

Traditionally, people who had undergone abdominal surgery were kept nil-by-mouth postoperatively until evidence of bowel motility was observed. After this, individuals would begin with a clear liquid diet and slowly advance to a regular diet. (1) The rationale behind this was to allow the bowel to rest and to reduce the likelihood of complications such as anastomotic dehiscence, aspiration pneumonia, bowel distension, bowel obstruction and nausea and vomiting. However, delayed or inadequate post-operative nutrition has been associated with poor clinical outcomes such as an increased risk of complications. (2) Some studies have explored the safety of early postoperative feeding and shown that the postoperative fasting period can be reduced without compromising patient safety. (3, 4) Furthermore, early feeding has been associated with earlier return of gastrointestinal function, and improvements in complication rates and quality of life (summarised in (5)).

Early postoperative feeding has been incorporated into the Enhanced Recovery After Surgery (ERAS) programme, which is a programme of around 20 evidence-based care practices for the perioperative period. The aim of ERAS is to reduce the overall surgical stress response and thereby accelerate recovery and improve outcomes. (6) ERAS has been associated with substantial benefits to both patients and healthcare systems including an approximate two-day reduction in hospital stay following colorectal surgery. (7) In a systematic review of colorectal surgery studies in which compliance to individual ERAS components was reported, compliance with early postoperative feeding ranged from 13 to 100% (n=9 studies). (8) Only three of the included studies were either conducted in, or included data from, the UK, and the extent to which early postoperative feeding is implemented within ERAS settings remains unclear.

Relatively few studies in colorectal surgery populations have looked at factors associated with early postoperative feeding. Some have suggested that early mobilisation (9) and shorter surgery duration (10) are associated with the success of early feeding or early tolerance, respectively, and systematic reviews and meta-analyses reported reduced time to food intake with laparoscopic (compared to open) surgery for the treatment of low rectal cancer (11) or choledochal cysts in children. (12) Other studies have shown that surgery for malignancy, ASA grade >2, and age >75 years, (13) blood loss during the operation, (10, 14) and poor pre-operative nutritional status (15) are associated with delayed post-operative feeding or tolerance. A recent prospective observational study conducted in Australia (16) reported that gastrointestinal surgery populations often experienced delays in time to any nutrition or commencement of solid foods compared to other surgical populations. Organisational (e.g., no meal provided when it had been prescribed), professional (e.g., reluctance to commence on solid foods) and patient-related factors (e.g., poor appetite) all contributed to this. Qualitative investigations in colorectal surgery populations have shown that people associate post-operative feeding with a sense of returning to 'normality' (17, 18), but reported mixed views on when people were willing to commence solid foods (i.e., sooner or later than when prescribed) (17).

In this study, we used data from a previously conducted trial of chewing gum after colorectal surgery (19) for a post hoc analysis of early postoperative feeding practices and to look at potentially modifiable factors that could be explored in future studies designed to address associations with early feeding. As such, the aims of this study were to describe post-operative feeding practices in a colorectal surgery population in the UK, and to generate hypotheses for testing in future studies.

Materials and Methods

Data collection

Data for this hypothesis-generating observational study were from a previously conducted randomised controlled trial of post-operative chewing gum after elective resectional colorectal surgery, which has been described in detail elsewhere. (19) Briefly, between October 2010 and April 2013, 745 individuals scheduled to undergo colorectal surgery in five hospitals in England that routinely used ERAS programmes (Bristol Royal Infirmary, Derriford Hospital Plymouth, Yeovil District Hospital, Torbay Hospital and Queen's Medical Centre Nottingham) were assessed for eligibility. Patients were ineligible if they were aged < 18 years, had Crohn's disease, were operated on as an emergency, were pregnant or lactating, were participating in another study that could undermine the scientific basis of the present trial, or were deemed unsuitable (e.g., incapable of providing adequate responses/information or consent to participate). 412 individuals were recruited and randomised to receive either post-operative chewing gum four times a day for the first five days post-operation, or usual care. Five individuals per treatment group were subsequently withdrawn by investigators to give a final sample size of 402 (a sample size of 400 was estimated for the parent trial, based on the primary outcome of length of hospital stay (19)). As previously reported, there was little difference between treatments in outcomes such as length of hospital stay and complications. (19) Data from both treatment groups (chewing gum and control) were therefore combined for this observational study, and trial arm was included as an adjustment variable.

As previously described, (19) data on participant characteristics were obtained from questionnaires and included data on age, gender, education, body mass index (BMI), ethnicity, and smoking status. Data on peri-operative factors were obtained primarily from

patient records and included information on whether patients were given pre-operative bowel preparation (including oral bowel preparations, phosphate enema, or combined oral and enema) and pre-operative diet preparations (including supplement drinks, rehydration salts, and 'pre-Op' cartons), and patients' American Society of Anaesthesiologists (ASA) physical status classification system grade. Data were also collected on surgical approach, primary procedure, and stoma formation, and if anti-emetics and opiate analgesics had been prescribed on the day of operation or post-operative day (POD) 1.

Participants were asked to record whether they had vomited on PODs 1-5. Solid food intake on PODs 1-5 was obtained by asking participants to record the proportion of each of three meals (breakfast, lunch, evening meal) consumed in a day as: none, a quarter, half, three quarters, all. The data collection instrument was designed specifically for this study as a means of obtaining general estimates of solid food intake and was not validated against other methods. Based on the type of data available, we created definitions for early consumption and tolerance of solid food as follows: early consumers were classed as those who reported consuming at least a quarter of a meal on POD 1 (this was the minimum amount that people could report having consumed); participants who reported any solid food consumption later than POD 1 were classed as delayed consumers. Tolerance of solid food was defined in this study as the consumption of at least half of three meals in a day without vomiting. Participants who tolerated food early were those who tolerated solid food on POD 1 or 2. Participants who tolerated food later than POD 1 or 2 were classed as delayed. See (19) for more detail on data collection.

Data from study participants are anonymised. All study procedures for the main trial were approved by the National Research Ethics Service Committee South West (REC reference

number 09/H0106/37), and all study participants provided written informed consent. The trial is registered in the ISRCTN registry (ISRCTN55784442).

Data analysis

The choice of exposures to explore in relation to post-operative dietary intakes was based on previously published associations or biological plausibility, combined with pragmatic decisions regarding amounts of missing data in the parent trial dataset. The exposures investigated were: indication for surgery (delayed tolerance of early feeding was associated with surgery for malignancy in a previous study (13)); provision of pre-operative bowel preparation (we previously showed that use of pre-operative bowel preparation had a negative impact on peri-operative nutritional experiences (18)); provision of pre-operative diet preparation (some studies have suggested that pre-operative carbohydrate loading may decrease post-operative hunger (20, 21)); surgical approach (there is some evidence that patients undergoing laparoscopic surgery have earlier food intake than those undergoing open surgery (12, 22, 23)); primary procedure (the extent of the surgical 'insult' could conceivably affect post-operative dietary intakes); stoma formation (patients may have different attitudes towards food if they have had a stoma placed (18, 24)), POD 0/1 anti-emetics (control of nausea and vomiting through use of anti-emetics could conceivably affect post-operative dietary intakes); POD 0/1 opiate analgesics (use of opiates is associated with onset of ileus (25, 26) which, in turn, has been associated with intolerance of solid food (27)). Data for some exposures that were available in the parent trial (19) were not explored given the inter-relationship with variables already being considered (e.g., nausea was not considered because POD 0/1 anti-emetics was already included, and length of operation was not considered because procedure type was already included).

We defined our study sample as those from the parent trial who had complete data for the exposures and outcomes of interest and potential confounders. To determine whether there were systematic differences between those included in or excluded from this analysis we compared the groups with regards to the exposure, outcome and confounder variables using chi-square tests for categorical variables, and t-tests/Mann-Whitney U tests for normally/non-normally distributed continuous data.

We used logistic regression models to explore the effects of the exposures on the odds of early feeding or tolerance. We derived odds ratios for potential associations between each exposure and early consumption or early tolerance of solid food, adjusted for age, gender and trial arm; we then included all potential confounders (age, gender, trial arm, education, BMI, ethnicity, smoking status, indication for surgery, ASA grade, EQ5D); and in the fully adjusted regression model we included all exposures and all potential confounders. Due to the potential impact of multicollinearity we reported the variance inflation factor (VIF) and considered a VIF $\leq$10 to indicate that multicollinearity was not a concern. All analyses were undertaken using Stata 14 (StataCorp, 2015).

In order to explore potential differences in associations between our outcomes and the mode of administration of bowel preparation (oral or enema) we repeated our fully adjusted analyses with a modified version of our bowel preparation variable which included the mode. Due to further missing values for this variable we conducted this analysis as a sensitivity analysis, in order to preserve the sample size in our main analyses.

Results

Study sample

Complete data on exposures, potential confounders, and outcomes were available for 301 of the 402 trial participants and were included in this exploratory analysis. Participant demographics are shown in Table 1, and relevant peri-operative factors are shown in Table 2. Participants ranged in age from 20 to 95 years (median 67 years), and BMI ranged from 18.1 to 49.2 (median 26.5 kg/m^2). Most participants were male, and almost all were white and had undergone surgery for colorectal cancer. Approximately half underwent open/converted to open procedures, and half had a laparoscopic or laparoscopic assisted procedure. Around one third had a stoma placed.

Overall, when comparing those included in this analysis (i.e., those with 'complete' data) with those who had incomplete data, few differences between groups were observed for most exposures, outcomes and confounders (Supplementary Table 1). A higher proportion of people included in this study had received bowel preparation prior to surgery and had undergone higher education compared with those not included (71.4% vs 49.5% received bowel preparation, 35.2% vs 21.3% completed higher education respectively). There were also minor differences in age (people included in this study were slightly younger than those not included) and primary procedure (a higher proportion of those included had a rectal resection rather than other procedures, compared to those who were not included).

Early vs. delayed consumption of solid food

Using our definition of early and delayed consumption, 222 (73.8%) individuals had an early time to consumption of solid food (i.e., on POD 1) (Table 2).

Suggested associations between peri-operative factors and time to consumption of solid food are shown in Table 3 (minimally adjusted and intermediate models in Supplementary Table 3). In the fully adjusted model, provision of pre-operative bowel preparation was associated with delayed time to consumption of solid food [odds ratio (OR) 0.34, 95% confidence interval (CI) 0.14-0.83]. The association between bowel preparation and delayed time to feeding did not differ between oral bowel preparation or the use of an enema (OR 0.31, 95% CI 0.11-0.88 for oral, OR 0.41, 95% CI 0.16-1.03 for enema). There was weak evidence that having a total colectomy compared to rectal resection was associated with reduced odds of early consumption (OR 0.23, 95% CI 0.07-0.92), although this was only seen in the fully adjusted model and the confidence interval around the effect size estimate was large. VIFs were all <10 and therefore the regression models were not modified to account for multicollinearity (Supplementary table 2).

Early vs. delayed tolerance of solid food

Using our definition of tolerance, 109 (36.2%) individuals had an early time to tolerance of solid food, and 192 (63.8%) had delayed time to tolerance (Table 2). Seventy-four (38.5%) people with delayed time to tolerance vomited on POD 1 or 2, 86 (44.8%) had started eating by POD 2 without vomiting but ate less than half of three meals a day, and 32 (16.7%) did not start eating until POD 3 or later.

Suggested associations between peri-operative factors and time to tolerance of solid food are shown in Table 4 (minimally adjusted and intermediate models in Supplementary Table 4). Similar to the findings for solid food consumption, provision of pre-operative bowel preparation was associated with delayed time to tolerance of solid food (OR 0.35, 95% CI 0.16-0.81), and associations did not differ between oral bowel preparation or the use of an

enema (OR 0.25, 95% CI 0.09-0.68 for oral, OR 0.37, 95% CI 0.15-0.90 for enema). Laparoscopic/laparoscopic assisted procedures, compared to open/converted to open procedures, were associated with increased odds of tolerating solid food early (OR 1.99, 95% CI 1.17-3.39). Having a left-sided colectomy compared to a rectal resection was also associated with increased odds of tolerating food early (OR 2.62, 95% CI 1.18-5.84). The confidence intervals around other relatively large effect estimates included the null value [e.g., reduced odds of early tolerance of solid food with total colectomy compared to rectal resection (OR 0.19, 95% CI 0.03-1.07)]. VIFs were all <10 and therefore the regression models were not modified to account for multicollinearity (Supplementary table 2).

Further exploration of bowel preparation associations

We further considered that the provision of pre-operative bowel preparation may vary according to primary procedure. Among those given bowel preparation, the majority (58%) underwent rectal resection. Among those who were not given bowel preparation, the majority (69%) underwent right-sided colectomy (Supplementary table 5a). We repeated our fully adjusted analyses of early consumption and tolerance stratified by procedure type. We restricted these analyses to the two main procedure sub-groups [right-sided colectomy (n=82) and rectal resection (n=138)] due to small numbers in the other sub-groups. Our findings support our primary analysis that the provision of pre-operative bowel preparation is associated with delayed time to consumption and tolerance of solid food, irrespective of the procedure type (Supplementary table 5b).

Discussion

Early post-operative feeding is recommended within ERAS programmes, and may be associated with earlier return of gastrointestinal function, and possibly with improvements in

complication rates and quality of life (summarised in (5)). In this colorectal surgery population, using our definitions for consumption and tolerance of solid food, three quarters of people reported consuming solid food on POD 1, but only one third reported tolerating solid food on POD 1 or 2. Exploration of the data suggest that future studies targeted towards improving early feeding and tolerance of solid food should consider minimising the use of pre-operative bowel preparation and promoting the use of laparoscopic/laparoscopic assisted surgery.

Few previous studies have explored adherence to early post-operative feeding protocols, or the extent to which early postoperative feeding is tolerated by patients. In a systematic review of colorectal surgery patients, compliance with early postoperative feeding across nine studies ranged from 13 to 100%. (8) More recently, another systematic review looked at post-operative feeding practices in relation to whether evidence-based guidelines were being met. (5) It was shown that few studies reported time to first feed/solid feed in line with recommendations, and those undergoing gastrointestinal procedures were more likely than other surgery types to experience delayed post-operative feeding. The findings from our post-hoc analysis suggest reasonable compliance in this population with the early feeding component of the ERAS programme, since three quarters reported consuming some solid food on POD1. However, tolerance of solid food on POD 1 or 2 was much poorer. We did not formally explore reasons for this, but a recent qualitative investigation from Australia provided an insight into the experiences and perceptions of post-operative feeding in people who had undergone colorectal surgery (17). In addition to service-level factors, several patient-related factors may influence whether or not people eat, or indeed tolerate, early oral feeding. For example, the choice of food in regards to both timing (i.e., when first prescribed) and type was shown to be important, especially in relation to individual perceptions of

whether or not they would be able to ‘stomach’ the food. In addition, good communication of diet-related messages from healthcare providers was also shown to be a key factor in shaping (improving) food intake behaviours.

We created a definition of tolerance of solid food for the purposes of this study using a combination of food consumption and vomiting data. In another study, the return of gut function was considered to be when more than 80% of required calories by the oral route was tolerated over a period of 48 hours. (28) We were unable to use caloric intake in our definition of tolerance, given that dietary data were not collected in sufficient detail to allow the calculation of energy intakes. Nonetheless, our findings suggest that future studies may want to consider a measure of tolerance of solid food intake (i.e., that includes data on vomiting) rather than just looking at solid food intake alone, as the latter could potentially give a false sense of return to ‘normality’ regarding postoperative dietary intake.

Our findings are somewhat in agreement with other studies. For example, we observed an association between laparoscopic/laparoscopic assisted surgery and earlier time to tolerance (although not time to resumption) of solid food. Systematic reviews and meta-analyses of studies in low rectal surgery in adults and in choledochal cyst surgery in children have shown reduced time to food intake or resumption of diet with laparoscopic compared to open abdominal surgery. (11, 12) It is possible that these associations are due to effects on post-operative ileus (which is associated with intolerance of solid food (27)), as laparoscopic surgery has been associated with reduced incidence and duration of ileus compared to open surgery. (29) In our study it might have been expected that anti-emetics would be associated with early post-operative feeding and that opioid analgesics would be associated with delayed post-operative feeding, but our findings did not show this (although the direction of effect

was generally consistent with this in the fully adjusted models, albeit with wide confidence intervals). It is possible that prophylactic anti-emetics would be associated with early post-operative feeding, but relatively few individuals were prescribed anti-emetics in this study suggesting that they were prescribed for the relief of symptoms rather than as a prophylactic measure. However, this study was not designed specifically to look at associations between anti-emetics / opioid analgesics and early post-operative feeding, and further studies are needed to fully explore this.

ERAS guidelines recommend against mechanical bowel preparation (MBP) prior to abdominal surgery (30). However, the relationship between MBP and recovery of bowel function is unclear. For example, meta analyses have shown no benefit of MBP prior to colonic surgery (reviewed in (31), but a recent observational study suggested that MBP in combination with antibiotics is associated with improved outcomes of colorectal surgery such as reduced surgical site infection, anastomotic leak, and postoperative ileus (32). If pre-operative bowel preparation is associated with improved recovery of bowel function, it is plausible that pre-operative bowel preparation may be associated with improved postoperative dietary intakes. Our post-hoc analysis did not suggest this, although confirmation of these findings in a study designed to assess such an association is needed. The proportion of people receiving bowel preparation in our study was relatively high, especially in light of ERAS recommendations to avoid MBP prior to abdominal surgery (30). However, it is similar to the proportion (approximately 73%) that received MBP (either with or without antibiotics) in an observational study of people undergoing colorectal surgery in the United States (32). Fewer people with incomplete data (i.e., not included in this study) had received bowel preparation prior to surgery (49.5%) than those who were included (71.4%). The reasons for this are not clear but could be due to chance. ERAS guidelines also

recommend the routine use of preoperative oral carbohydrate treatment (30), and some previous studies have suggested that preoperative carbohydrate loading may lead to decreased postoperative hunger. (20, 21) Again, our post-hoc analysis did not suggest such an association, although a suitably designed study is needed for confirmation of associations.

A major strength of this study is that the data were from a large trial in a colorectal surgery population, and data on several outcomes had been collected. Furthermore, the study participants were recruited from hospitals in England that routinely used ERAS programmes which is of relevance to current practice. We used a subset of people from the parent trial (that had complete data for the variables of interest), but there were few differences between those included and excluded from analyses. The differences that were observed may have been due to chance, given the number of comparisons that were made. We did not use a standardised definition of tolerance of solid food, but the inclusion of vomiting within our definition may have resulted in a more sensitive recovery parameter than simply looking at time to first consumption of solid food, as it may be more representative of normality with respect to dietary intakes.

There are also some limitations with this study. The data were not specifically collected to address the aims of this study, and data for some variables including solid food intake were not collected using standardised methodology and we did not validate the methods that were used. As such, the accuracy of the patient's estimation of the amount of food eaten on each day is not known. It has been shown that individuals recognise post-operative dietary intake as a discharge criterion, (18) and it is possible that this may influence their recall of such events. Furthermore, and as noted above, we could not define tolerance of food in line with a previously used definition (which used caloric intake via the oral route over a 48-hour period)

(28) as we did not collect data on absolute caloric intake. However, although not ideal, we were able to obtain patient perceived intakes for a relatively large population of individuals undergoing colorectal surgery. Another limitation is that there were no centralised protocols for anaesthetic, analgesic or anti-emetic use across study sites, and although we recorded crude details of these it was beyond the scope of this study to consider the many different combinations which may have been used. Other limitations, as noted previously, (19) are that data for some variables of interest, e.g., early mobilisation (which was associated with early feeding in a study by Stewart et al., (9)) were not collected, some were collected only post-operatively and not peri-operatively (e.g., use of antiemetics), some were infrequently reported (e.g., use of NG tubes) rendering them unsuitable as an adjustment variable, and other variables had large amounts of missing data which precluded their inclusion in analyses. Relatively few variables from the parent trial were included in our analyses because several variables were considered interrelated, and their inclusion in analyses would have resulted in difficulty in teasing out which variable was driving an association, or over-adjustment in analyses. Given the observational nature of this study it is not possible to determine causality. In addition, the study population had been recruited from hospitals in England and the findings may not be generalisable to other countries and healthcare systems. Finally, we included several confounders in our models, but there may be unmeasured confounders that are responsible for the observed associations.

In conclusion, almost three quarters of the people in this study population reported that they ate solid food early but only one third tolerated solid food early, albeit using a non-standardised definition of tolerance. Our findings suggest that avoidance of bowel preparation and laparoscopic surgery are potentially associated with early post-operative feeding. Targeting these ERAS components may improve early feeding and tolerance of solid food,

which may ultimately contribute to a faster recovery from colorectal surgery.

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Statement of Authorship

Contribution of authors: Conception and design (CA, VCM, ARN, SJT, CMP), analysis (VCM, SDL, CMP), interpretation of the data (CA, VCM, ARN, SJL, RJL, SJT, SDL, WH, CMP), drafting the initial version of the manuscript (CA, VCM, CMP), and critically revising the manuscript for intellectual content (CA, VCM, ARN, SJL, RJL, SJT, SDL, WH, CMP). All authors (CA, VCM, ARN, SJL, RJL, SJT, SDL, WH, CMP) have approved the final version submitted for publication.

Conflict of Interest Statement

All authors have no conflicts of interest to declare.

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514 expressed in this publication are those of the authors and not necessarily those of the NHS,
515 the National Institute for Health Research or the Department of Health and Social Care.
516

517 Table 1. Participant characteristics (n=301)

Characteristic	**Category**	**Frequency (%)**
Age group (years)	<60	78 (25.9%)
	60-69	100 (33.2%)
	≥70	123 (40.9%)
Gender	Male	178 (59.1%)
	Female	123 (40.9%)
Education[1]	None/compulsory	195 (64.8%)
	Further education	106 (35.2%)
BMI (kg/m^2)	<25	113 (37.5%)
	25 to <30	110 (36.5%)
	≥ 30	78 (25.9%)
Ethnicity	White	294 (97.7%)
	Other	7 (2.3%)
Smoking status	Current	25 (8.3%)
	Former	163 (54.2%)
	Never	113 (37.5%)
Indication for surgery	Colorectal neoplasia	280 (93.0%)
	Diverticular disease	10 (3.3%)
	Ulcerative colitis	11 (3.7%)
ASA grade	I	39 (13.0%)
	II	201 (66.8%)
	III	61 (20.3%)
EQ-5D-3L quality of life score[2]	-	0.8 (0.2)
Trial arm	Chewing gum	148 (49.2%)

	Usual care	153 (50.8%)

[1] Compulsory = school qualification to age 16 (i.e. to 'O' level/GCSE/school certificate/equivalent); further = 'A' level/equivalent or degree

[2] Data presented as mean (± SD)

522 Table 2. Perioperative factors (n=301)

		Frequency (%)
Provision of bowel preparation	Yes	215 (71.4%)
	Oral	*n=100*
	Enema	*n=98*
	Both	*n=5*
	Other/unknown	*n=12*
	No	86 (28.6%)
Provision of pre-operative diet preparation	Yes	277 (92.0%)
	No	24 (8.0%)
Surgical approach	Open/converted to open	146 (48.5%)
	Laparoscopic/laparoscopic assisted	155 (51.5%)
Primary procedure	Total colectomy	15 (5.0%)
	Right-sided colectomy	82 (27.2%)
	Left-sided colectomy	49 (16.3%)
	Rectal resection	138 (45.8%)
	Other[3]	17 (5.6%)
Stoma placed	Yes	104 (34.6%)
	No	197 (65.4%)
POD 0/1 anti-emetics prescribed	Yes	70 (23.3%)
	No	231 (76.7%)
POD 0/1 opiate analgesics prescribed	Yes	100 (33.2%)
	No	201 (66.8%)
Consumption of solid food[1]	Early	222 (73.8%)
	Delayed	79 (26.2%)

Tolerance of solid food[2]	Early	109 (36.2%)
	Delayed	192 (63.8%)

[1] 'Early' = consumption of solid food reported on post-operative day (POD) 1; 'Delayed' = POD 2 or later

[2] 'Early' = the consumption of at least half of three meals in a day without vomiting on POD 1 or 2; 'Delayed' = POD 3 or later

[3] Includes procedures such as a partial resection or small bowel resection

Table 3. Associations between demographic and peri-operative factors and early vs. delayed consumption of solid food[1]

				Fully adjusted[3]	
		Early, n (%)	Delayed, n (%)	OR (95% CI)	P
Provision of pre-operative bowel preparation	*No*	72 (32.4%)	14 (17.7%)		
	Yes	150 (67.8%)	65 (82.3%)	0.34 (0.14-0.83)	0.02
Provision of pre-operative diet preparation	*No*	16 (7.2%)	8 (10.1%)		
	Yes	206 (92.8%)	71 (89.9%)	2.04 (0.74-5.67)	0.17
Surgical approach	*Open/converted to open*	103 (46.4%)	43 (54.4%)		
	Laparoscopic/lap. assisted	119 (53.6%)	36 (45.6%)	1.49 (0.85-2.60)	0.16
Primary procedure	*Rectal resection*	100 (45.1%)	38 (48.1%)		
	Total colectomy	8 (3.6%)	7 (8.9%)	0.26 (0.07-0.92)	0.04
	Right-sided colectomy	64 (28.8%)	18 (22.8%)	0.73 (0.28-1.91)	0.52

	Left-sided colectomy	38 (17.1%)	11 (13.9%)	1.46 (0.61-3.50)	0.40
	Other[2]	12 (5.4%)	5 (6.3%)	0.60 (0.17-2.12)	0.43
Stoma placed	*No*	148 (66.7%)	49 (62.0%)		
	Yes	74 (33.3%)	30 (38.0%)	0.94 (0.48-1.85)	0.86
POD0/1 anti-emetics	*No*	172 (77.5%)	59 (74.7%)		
	Yes	50 (22.5%)	20 (25.3%)	0.53 (0.21-1.33)	0.18
POD0/1 opiate analgesics	*No*	146 (65.8%)	55 (69.9%)		
	Yes	76 (34.2%)	24 (30.4%)	1.86 (0.79-4.41)	0.16

[1] Early consumers were classed as those who ate at least a quarter of a meal on post-operative day 1

[2] Includes procedures such as a partial resection or small bowel resection

[3] Fully adjusted model: Minimally adjusted model (age, gender and trial arm) + Intermediate model (education, BMI, ethnicity, smoking status, indication for surgery, ASA grade, EQ5D) + adjusted for all other clinical exposures

Table 4. Associations between demographic and peri-operative factors and early vs. delayed tolerance of solid food[1]

				Fully adjusted[3]	
		Early, n (%)	Delayed, n (%)	OR (95% CI)	P
Provision of pre-operative bowel preparation	*No*	39 (35.8%)	47 (24.5%)		
	Yes	70 (64.2%)	145 (75.5%)	0.35 (0.16-0.81)	0.01
Provision of pre-operative diet preparation	*No*	9 (8.3%)	15 (7.8%)		
	Yes	100 (91.7%)	177 (92.2%)	1.25 (0.47-3.34)	0.66
Surgical approach	*Open/converted to open*	44 (40.4%)	102 (53.1%)		
	Laparoscopic/lap. assisted	65 (59.6%)	90 (46.9%)	1.99 (1.17-3.39)	0.01
Primary procedure	*Rectal resection*	47 (43.1%)	91 (47.4%)		
	Total colectomy	2 (1.8%)	13 (6.8%)	0.19 (0.03-1.07)	0.06
	Right-sided colectomy	30 (27.5%)	52 (27.1%)	0.93 (0.36-2.42)	0.89

	Left-sided colectomy	22 (20.2%)	27 (14.1%)	2.62 (1.18-5.84)	0.02
	Other[2]	8 (7.3%)	9 (4.7%)	1.67 (0.49-5.65)	0.41
Stoma placed	*No*	72 (66.1%)	125 (65.1%)		
	Yes	37 (33.9%)	67 (34.9%)	1.30 (0.67-2.54)	0.44
POD1 anti-emetics	*No*	86 (78.9%)	145 (75.5%)		
	Yes	23 (21.1%)	47 (24.5%)	0.82 (0.36-1.87)	0.63
POD1 opiate analgesics	*No*	73 (67.0%)	128 (66.7%)		
	Yes	36 (33.0%)	64 (33.3%)	1.00 (0.48-2.09)	1.00

[1] Early tolerance was the consumption of at least half of three meals on post-operative days 1 or 2 without vomiting

[2] Includes procedures such as a partial resection or small bowel resection

[3] Fully adjusted model: Minimally adjusted model (age, gender and trial arm) + Intermediate model (education, BMI, ethnicity, smoking status, indication for surgery, ASA grade, EQ5D) + adjusted for all other clinical exposures

Supplementary Table 1 A comparison of people with incomplete and complete data

Characteristic	**Level**	**Frequency (%)**		**P**[1]
		Incomplete (max n=101)	**Complete (n=301)**	
Trial arm	Usual care	50 (49.5%)	153 (50.8%)	0.82
	Chewing gum	51 (50.5%)	148 (49.2%)	
Age group (years)	<60	19 (18.8%)	78 (25.9%)	0.15
	60-69	30 (29.7%)	100 (33.2%)	
	≥70	52 (51.5%)	123 (40.9%)	
Gender	Male	52 (51.5%)	178 (59.1%)	0.18
	Female	49 (48.5%)	123 (40.9%)	
Education	None/compulsory	59 (78.7%)	195 (64.8%)	0.022
	Further education	16 (21.3%)	106 (35.2%)	
BMI (kg/m^2)	<25	40 (40.4%)	113 (37.5%)	0.75
	25 to <30	32 (32.3%)	110 (36.5%)	
	≥ 30	27 (27.3%)	78 (25.9%)	
Ethnicity	White	91 (96.8%)	294 (97.7%)	0.64
	Other	3 (3.2%)	7 (2.3%)	
Smoking status	Current	10 (11.0%)	25 (8.3%)	0.72
	Former	47 (51.6%)	163 (54.2%)	
	Never	34 (37.4%)	113 (37.5%)	
Indication for surgery	Colorectal neoplasia	92 (91.1%)	280 (93.0%)	0.49
	Diverticular disease	6 (5.9%)	10 (3.3%)	
	Ulcerative colitis	3 (3.0%)	11 (3.7%)	

ASA grade	I II III	10 (13.2%) 43 (56.6%) 23 (30.3%)	39 (13.0%) 201 (66.8%) 61 (20.3%)	0.16
EQ-5D-3L quality of life score	-	0.8 (0.2)	0.8 (0.2)	0.29
Provision of bowel preparation	Yes No	49 (49.5%) 50 (50.5%)	215 (71.4%) 86 (28.6%)	<0.001
Provision of pre-operative diet preparation	Yes No	89 (89.9%) 10 (10.1%)	277 (92.0%) 24 (8.0%)	0.51
Surgical approach	Open/converted to open Laparoscopic/laparoscopic assisted	52 (52.5%) 47 (47.5%)	146 (48.5%) 155 (51.5%)	0.49
Primary procedure	Total colectomy Right-sided colectomy Left-sided colectomy Rectal resection Other[1]	5 (5.1%) 35 (35.4%) 20 (20.2%) 30 (30.3%) 9 (9.1%)	15 (5.0%) 82 (27.2%) 49 (16.3%) 138 (45.8%) 17 (5.6%)	0.092
Stoma placed	Yes No	32 (32.3%) 67 (67.7%)	104 (34.6%) 197 (65.4%)	0.68
POD started eating	Late - POD 2-5 Early - POD 1	14 (24.6%) 43 (75.4%)	79 (26.2%) 222 (73.8%)	0.79
POD food tolerated	Late - POD 3-5 Early - POD 1 or 2	38 (66.7%) 19 (33.3%)	192 (63.8%) 109 (36.2%)	0.68
POD0/1 anti-emetics	Yes No	16 (15.8%) 85 (84.2%)	70 (23.3%) 231 (76.7%)	0.12

POD0/1 opiate analgesics	Yes	25 (24.8%)	100 (33.2%)	0.11
	No	76 (75.2%)	201 (66.8%)	

[1] All P-values were derived from chi-square tests unless otherwise stated

[2] P-value derived from a t-test

Supplementary Table 2: Assessment of multicollinearity in the fully adjusted regression models of early consumption and early tolerance of solid food

Variable	Level	Variance Inflation Factor
Bowel preparation	Yes	1.93
	No	
Diet preparation	Yes	1.08
	No	
Surgical approach	Open/converted to open	
	Laparoscopic/lap. assisted	1.06
Primary procedure	Rectal resection	
	Total colectomy	1.18
	Right-sided colectomy	2.59
	Left-sided colectomy	1.40
	Other	1.20
Stoma placed	Yes	1.51
	No	
POD0/1 anti-emetics	Yes	1.89
	No	
POD0/1 opiate analgesics	Yes	1.90

	No	
Age group (years)	<60	
	60-69	1.95
	≥70	2.08
Gender	Male	
	Female	1.19
Education	None/compulsory	
	Further education	1.14
BMI (kg/m^2)	<25	
	25 to <30	1.43
	≥ 30	1.44
Ethnicity	White	
	Other	1.11
Smoking status	Current	
	Former	3.84
	Never	3.93
Indication for surgery	Colorectal neoplasia	
	Diverticular disease	1.21
	Ulcerative colitis	1.35

ASA grade	I II III	 2.33 2.73
EQ-5D-3L quality of life score[2]	-	1.27
Trial arm	Chewing gum Usual care	 1.06

Supplementary Table 4. Associations between demographic and peri-operative factors and early vs. delayed tolerance of solid food[1]

			Minimally adjusted[3]		Confounder adjusted[4]	
	Early, n (%)	Delayed, n (%)	OR (95% CI)	P	OR (95% CI)	P
Provision of pre-operative bowel preparation						
No	39 (35.8%)	47 (24.5%)				
Yes	70 (64.2%)	145 (75.5%)	0.50 (0.29-0.85)	0.01	0.48 (0.27-0.86)	0.01
Provision of pre-operative diet preparation						
No	9 (8.3%)	15 (7.8%)				
Yes	100 (91.7%)	177 (92.2%)	0.90 (0.37-2.19)	0.82	0.99 (0.40-2.46)	0.98
Surgical approach						
Open/converted to open	44 (40.4%)	102 (53.1%)				

Laparoscopic/lap. assisted	65 (59.6%)	90 (46.9%)	1.74 (1.07-2.83)	0.03	1.89 (1.14-3.13)	0.01
Primary procedure						
Rectal resection	47 (43.1%)	91 (47.4%)				
Total colectomy	2 (1.8%)	13 (6.8%)	0.34 (0.07-1.58)	0.17	0.24 (0.04-1.30)	0.10
Right-sided colectomy	30 (27.5%)	52 (27.1%)	1.36 (0.74-2.48)	0.32	1.63 (0.86-3.10)	0.14
Left-sided colectomy	22 (20.2%)	27 (14.1%)	1.78 (0.90-3.53)	0.10	2.11 (1.02-4.38)	0.05
Other[2]	8 (7.3%)	9 (4.7%)	2.06 (0.72-5.89)	0.18	1.76 (0.57-5.49)	0.33
Stoma placed						
No	72 (66.1%)	125 (65.1%)				
Yes	37 (33.9%)	67 (34.9%)	0.92 (0.55-1.54)	0.75	0.89 (0.52-1.53)	0.67
POD1 anti-emetics						
No	86 (78.9%)	145 (75.5%)				

Yes	23 (21.1%)	47 (24.5%)	0.89 (0.50-1.59)	0.69	0.78 (0.42-1.42)	0.41
POD1 opiate analgesics						
No	73 (67.0%)	128 (66.7%)				
Yes	36 (33.0%)	64 (33.3%)	1.00 (0.60-1.67)	1.00	0.90 (0.53-1.54)	0.70

[1] Early tolerance was the consumption of at least half of three meals on post-operative days 1 or 2 without vomiting

[2] Includes procedures such as a partial resection or small bowel resection

[3] Minimally adjusted model: adjusted for age, gender and trial arm

[4] Confounder adjusted ('intermediate') model: Minimally adjusted model + adjusted for remaining confounders (education, BMI, ethnicity, smoking status, indication for surgery, ASA grade, EQ5D)

Supplementary Table 5a Number of people provided with bowel preparation according to procedure type

Primary procedure	Provision of bowel preparation = yes	Provision of bowel preparation = no
Total colectomy	9 (4.2%)	6 (7.0%)
Right-sided colectomy	23 (10.7%)	59 (68.6%)
Left-sided colectomy	47 (21.9%)	2 (2.3%)
Other procedure	11 (5.1%)	6 (7.0%)
Rectal resection	125 (58.1%)	13 (15.1%)

Supplementary Table 5b Associations between the provision of bowel preparation and early vs. delayed consumption/tolerance of solid food for people having a right-sided colectomy or rectal resection

Outcome	Procedure sub-group			Early, n (%)	Delayed, n (%)	OR[1,2] (95% CI)	P
Consumption of solid food	Right-sided colectomy	Provision of bowel prep.	*No*	50 (78.1%)	9 (50.0%)	1	-
			Yes	14 (21.9%)	9 (50.0%)	0.06 (0.01-0.45)	0.006
	Rectal resection	Provision of bowel prep.	*No*	12 (12.0%)	1 (2.6%)	1	-
			Yes	88 (88.0%)	37 (97.4%)	-	0.993
Tolerance of solid food	Right-sided colectomy	Provision of bowel prep.	*No*	24 (80.0%)	35 (67.3%)	1	-
			Yes	6 (20.0%)	17 (32.7%)	0.19 (0.03-1.09)	0.063

	Rectal resection	Provision of bowel prep.	*No*	9 (19.2%)	4 (4.4%)	1	-
			Yes	38 (80.9%)	87 (95.6%)	0.09 (0.01-0.86)	0.036

[1] Fully adjusted model: Minimally adjusted model (age, gender and trial arm) + Intermediate model (education, BMI, ethnicity, smoking status, indication for surgery, ASA grade, EQ5D) + adjusted for all other clinical exposures

[2] Odds of early vs. delayed consumption/tolerance of solid food